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ON SNOW-STORMS

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1. Introduction

The developing conditions of snow-storm, shifting quantities of flying snow, vertical distribution of flying snow and so on have been studied by people concerned with counter-measures against snowdrift damages. Whereas numerous data are available on the developing conditions, sufficient data are hard to find on the shifting quantities and vertical distribution that have larger bearing in the problem of snowdrift. The authors, also engaged in the investigations on the performance of snow fences and shelterbelts, undertook some measurements of vertical distribution which was closely related with their theme of research. The data obtained are reported here.

2. Measuring procedure

For the measurement, a snow-receiving device was conceived. Various attempts were made- from a simple cylinder covered with a metal wire net at one end to a cyclone-type appartus with a suction blower and some others—until a contraption like Fig. 1 was found best.

Meanwhile a method to measure the concentration of flying snow by the photo-electric cell was tried but, difficult of handling and of calibration, it seemed unfit for the practical purpose.

Needless to say, the less the size of measuring appartus the more desirable. However, if it is too small, precision is detracted and the measuring procedure becomes difficult. Therefore, for the present test the dimensions shown by Fig. 1 were adopted on the results of a simplified model experiment in the wind tunnel.

Ten units of this device were prepared and fitted on a 5 m high pole in such manner that the opening faced to the windward side and they were spaced with closer intervals downward and wider intervals upward; thus a logarithmic distribution was obtained in the range of height between 5 cm and 5 m above the snow surface on the ground.

They were ready to be unfastened from the pole.

The measuring time was varied with different intensities of snow-storm. An approximately filled unit at the lowest level was the signal to take down all the units. By this procedure it sometimes happened that the measurement finished in mere five minutes in a wind blowing at 14 m/s (at the height of 1m). The greater part of the snow caught was heaped in the collection box; the rest of snow clinging everywhere in the interior was collected into the box. After that, the box was taken down and weighed on the balance scale.

Simultaneously the vertical distribution of wind velocity was measured by small cup anemometers.

Fig. 1 Snow-storm measuring device made of zinc-plated iron sheet 0.5 mm thick.

3. Vertical distribution of the quantity of drifting snow

The flat terrain near Higashinoshiro and Kado station, Akita Prefecture was chosen as the test site and the measurement took place in the period January-February 1952. The testing ground at Higashinoshiro was on the River Yonshiro; it was overgrown with weeds in some spots, making some unevenness on the surface of snow deposit.

The Kado testing site, being a paddy-field and extending to the Hachirogata lagoon, had an ideal terrain for testing.

The results of measurement are shown in Table 1 and 2 and Fig. 2 to 6; a similar tendency is noticeable in both cases.

Now suppose weight of snow caught in the measuring device at an arbitrary height is M_2. Then, with M_1 at 1 m height as basis the relation between log $\frac{M_2}{M_1} \times 100$ and the height Z is sought. As shown in Figs. 4 and 5 the lower part turns out linear and seems to fit the experimental formula,

$$Z = a\,(K - \log \frac{M_2}{M_1} \times 100) \quad \ldots\ldots \quad (a,\ K = \text{constants})$$

The constants a, and K have values as given in Table 1.

The part that deviates from the formula and represents a line sharply swerving upward shows presumably the influence of falling snow.

If the height of snowstorm is assumed at the point where M_2/M_1 reaches 0.1, it will be equal to 1-1.5 m, which seems too low judging from our experiences.

The wind velocity $\bar{u}$ was found distributed like Fig. 6, with $\log Z \propto \bar{u}$. The velocity at 1 m height was taken as typical and was shown in Figs. 2 and 3. The wind velocity was measured simultaneously with measurement of the quantity of drifting snow. As the measurement was conducted in the midst of raging storm, the appartus often got out of order and gave incomplete data. For this reason Fig. 2 and 3 are far from complete but at least point to the general trend at both test sites. The wind velocity is a three-minute average.

4. Conclusion

On account of the scarcity of data, the relation between the wind velocity in a snowstorm and the constants a, K is not fully known. So far as the wind velocity 6-15 m/s is concerned, however, it is surmised that there is no great difference among the magnitudes of these constants.

According to T. Hirata, the value of a is one digit larger (818 and 527). The authors intend to re-examine by increasing number of measurements under controllable meteorological conditions.

The height of snowstorm was determined by extrapolation of the lower linear portion of the Figure, so that the quantity of falling snow was approximately excluded. Strictly speaking, corrections should be made for the falling snow in accordance with the distribution of wind velocity.

Determination of the snow-receiving rate of the measuring apparatus will give the moving quantity of flying snow per unit of area in unit time, and therefrom the density of snowstorm and the total quantity of moving snow can be calculated. The authors wish to make measurements in the wind tunnel.

The measuring apparatus was generally satisfactory except that under a high velocity of wind, some snow was blown through it; it needs modification to prevent this.

The moving quantity of the part of snowstorm that is called "flowing snow"; i.e. the part blowing at the height below 5 cm may be approximately predicted from the Figure; the authors wish to make more precise measurements by some appropriate method. Measurements were tried with the collection box buried flush with the snow cover, but with no reliable data obtained.

References

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Table 1. Vertical Distribution of flying snow. (at Higashi Noshiro)

Z : height
M_2: weight of snow caught in measuring device
M_1: " at 1m. level

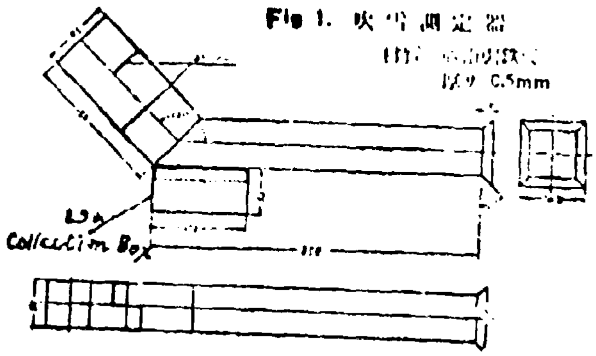
No.	Date	Z (cm)	M_2 (g)	$M_2/M_1 \times 100$	log $\frac{M_2}{M_1}$ 100	Duration	Air temp. (°C)	Wind Vel. (at 1m)(m/s)	experimental const. a	K
6	Jan.18,'52	12	22.6	492	2.69	1h 9h35m 10h35m	-5	8.9	52.1	2.92
		33	6.7	146	2.16					
		52	5.2	118	2.05					
		222	4.4	96	1.98					
		480	2.1	45	1.66					
		(100	4.6	100	2.00)					
7	Jan.18,'52	7	36.7	798	2.90	30m 10H55m 11H25m	-5	8.7	87.7	2.98
		27	32.7	711	2.85					
		58	6.4	139	2.14					
		222	3.5	76	1.88					
		480	3.4	74	1.87					
		(100	4.6	100	2.00)					
8	Jan.18,'52	5	37.2	809	2.91	20m 11h50m 12h10m	-5	8.2	75.8	2.98
		30	6.6	144	2.58					
		78	3.8	84	1.92					
		150	4.8	104	2.02					
		480	2.9	63	1.80					
		(100	4.6	100	2.00)					
19	Feb.10,'52	5	19.5	9760	3.90	10m 13h20m 13h30m	-2	5.5	35.2	4.04
		10	9.0	4500	3.65					
		20	4.3	2150	3.32					
		40	2.2	1100	3.04					
		70	0.8	400	2.60					
		100	0.2	100	2.00					
		200	0	-	-					

Table 2. Vertical distribution of flying snow (at Kado)

第2表 吹雪粒の濃度分布

No.	Date	Z (cm)	M (g)	$M_z/M_1 \times 100$	$\log \frac{M_z}{M_1} \times 100$	Duration	Air temp. (°C)	Wind vel. (at 1m) (m/s)	experimental const. $\left(Z = a \cdot K \log \frac{M_z}{M_1} \times 100\right)$ a	K
13	Feb.,'52 27.2.2	5	58.95	9830	3.99	1h (12h10m ~ 13h10m)	−5	14.0	43.5	4.02
		20	20.35	3395	3.51					
		45	9.80	1633	3.00					
		60	4.40	734	2.87					
		100	0.60	100	2.00					
		150	0.40	67	1.83					
		200	0.30	50	1.70					
		300	1.45	242	除外					
		400	0.40	67	1.83					
		500	0.60	100	2.00					
14	27.2.2	5	57.61	722	2.86	30m (14h55m ~ 15h25m)	−6	11.7	63.6	2.80
		10	37.03	474	2.68					
		30	13.05	166	2.22					
		60	10.80	138	2.14					
		100	7.86	100	2.00					
		150	5.93	76	1.88					
		200	5.77	74	1.87					
		300	6.50	83	1.92					
		400	5.75	74	1.86					
		500	4.02	51	1.71					
17	27.2.5	5	54.26	399	2.60	5m (13h48m ~ 14h 3m)	−8	14.0	90.0	2.55
		10	29.60	218	2.34					
		30	22.40	165	2.22					
		60	19.32	142	2.15					
		100	13.60	100	2.00					
		150	6.51	48	1.68					
		200	6.57	48	1.68					
		300	4.67	34	1.58					
		400	5.47	40	1.60					
		500	3.74	28	1.45					

Fig 1. 吹雪測定器
材料 [illegible]
厚サ 0.5mm



Unit: M.M.

Fig. 2. Vertical distribution of flying snow (at Higashinoshiro)

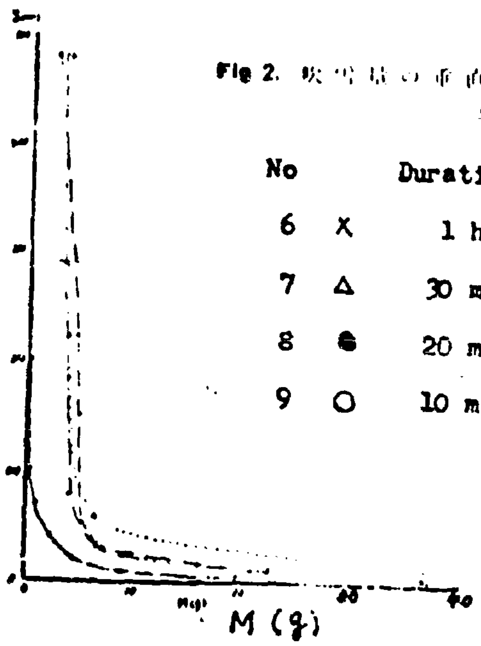
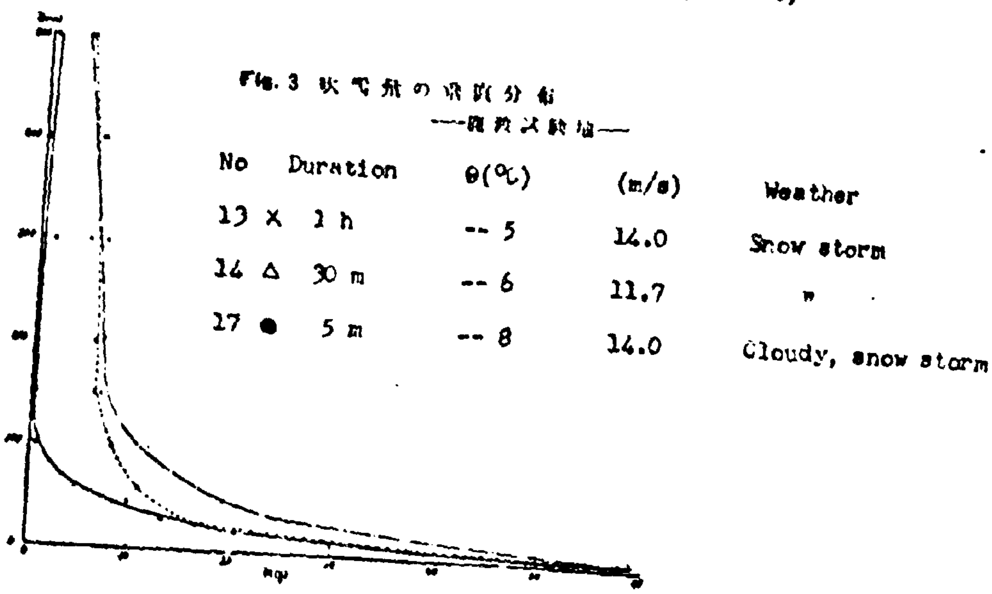
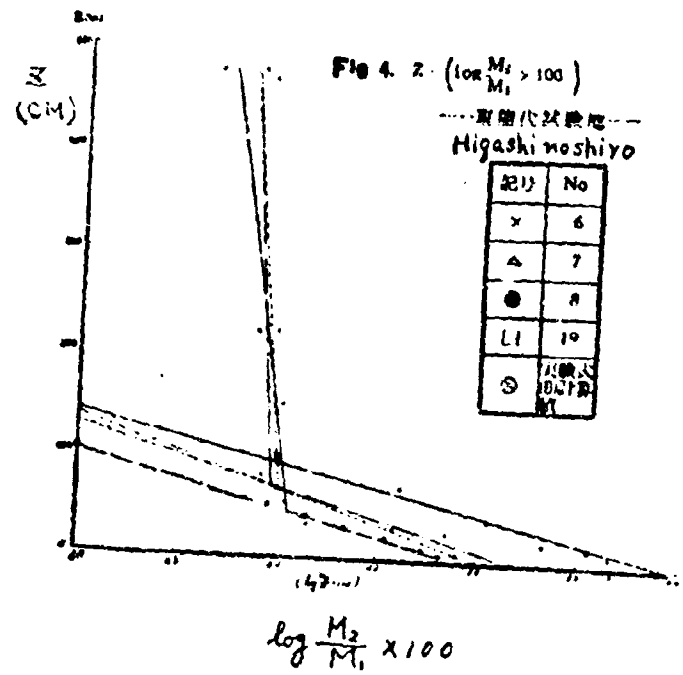


Fig 2. 吹雪量の垂直分布
東能代試験地

No		Duration	θ (°C)	(m/s)	Weather
6	X	1 h	− 5	8.9	Snow storm
7	△	30 m	− 5	8.7	"
8	●	20 m	− 5	8.2	"
9	O	10 m	− 2	5.5	Intermittently clear

Fig. 3. Vertical distribution of flying snow (at Kado)





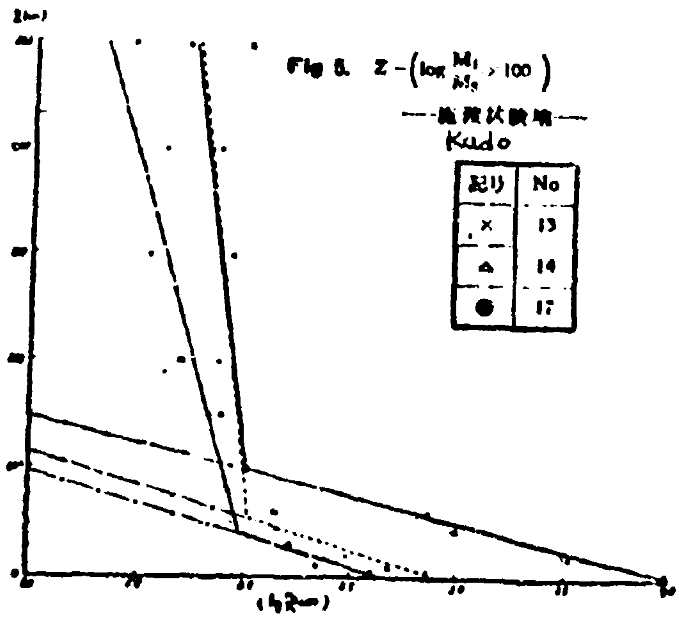


Fig. 6 Vertical distribution of wind velocity at experiment sites